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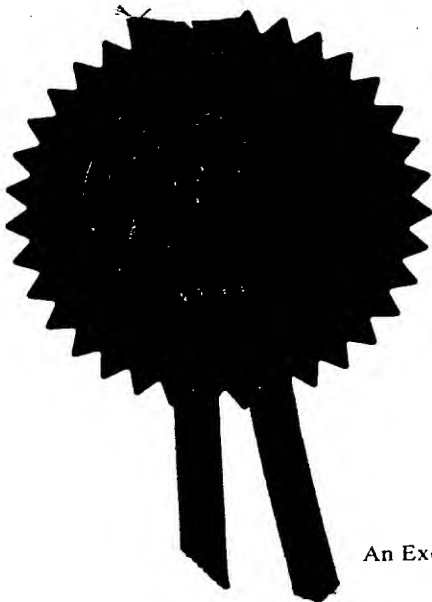
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F01/7700 0.00 - 9925486.4  
THE Patent Office  
Cardiff Road  
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1. Your reference

pre.683.uk.nmck2

2. Patent application

(The f

9925486.4

28 OCT 1999

3. Full name, address and postcode of the or of each applicant (underline all surnames)

Preston Associates (Scotland) Limited  
4 North Approach Road  
KINCARDINE ON FORTH  
FK10 4NH  
United Kingdom

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

UK

7769193001

4. Title of the invention

Plastic stretching method and apparatus for  
use in vacuum forming techniques

5. Name of your agent (if you have one)

"Address for service" in the United Kingdom  
to which all correspondence should be sent  
(including the postcode)

Kennedy & Co.  
Floor 4, Queen's House  
29 St Vincent Place  
GLASGOW  
G1 2DT  
United Kingdom

Patents ADP number (if you know it)

7283344002

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number  
(if you know it)Date of filing  
(day / month / year)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
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8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

No

- a) any applicant named in part 3 is not an inventor, or  
b) there is an inventor who is not named as an applicant, or  
c) any named applicant is a corporate body.  
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Description 10 ✓

Claim(s)

Abstract

Drawing(s) 4 ✓

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

Request for preliminary examination and search (Patents Form 9/77)

Request for substantive examination (Patents Form 10/77)

Any other documents (please specify)

11.

I/We request the grant of a patent on the basis of this application.

Signature Kennedy & Co.  
KENNEDY & CO.

Date  
28/10/99

12. Name and daytime telephone number of person to contact in the United Kingdom

Neil McKechnie  
tel: 0141 226 6826

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Patents Form 1/77

1 PLASTIC STRETCHING METHOD AND APPARATUS FOR USE IN VACUUM  
2 FORMING TECHNIQUES

3

4 The present invention relates in general to technology  
5 for stretching plastic sheets. In particular, the  
6 invention relates to the stretching of plastic sheets as  
7 a preparation step for use with vacuum forming  
8 techniques.

9

10 Vacuum forming techniques are used in a variety of  
11 industries; for example, bathroom furnishings such as  
12 baths can be vacuum formed from a single sheet of  
13 thermoplastic material. The thermoplastic material most  
14 commonly used for vacuum forming bathroom furnishings at  
15 the present time is acrylic.

16

17 In this manufacturing process, the cost of the  
18 thermoplastic sheet represents approximately 70% of the  
19 manufacturer's final costs. It would therefore be  
20 beneficial to find a method of using less thermoplastic  
21 in the manufacturing process. However, if one simply  
22 used a thinner sheet, one would expect to produce a final  
23 product with reduced mechanical strength.

1 It is therefore an aim of the present invention to  
2 provide a method and apparatus for producing vacuum  
3 formed goods that uses less thermoplastic than  
4 conventional techniques whilst retaining, or even  
5 improving, mechanical strength.  
6

7 We have found that a thermoplastic sheet, such as an  
8 acrylic sheet, which has been stretched before vacuum  
9 forming provides a final product which has greater  
10 mechanical strength than an unstretched sheet which has  
11 the same thickness at the start of the vacuum forming  
12 step.  
13

14 However, when one considers how to implement this  
15 stretching step industrially, a technical difficulty  
16 becomes apparent. When a plastic sheet is stretched it  
17 will scallop, that is to say that it will narrow in the  
18 middle with the sides bowing inwards. This means that it  
19 will not have a constant width and thickness throughout  
20 and cannot be cut efficiently into smaller square or  
21 rectangular portions.  
22

23 The aim of this invention is therefore to provide a  
24 method of stretching plastic sheets which can be used to  
25 expand the total surface area of the sheet without  
26 distorting the sheet, wasting material or having a non-  
27 uniform thickness. In particular, this invention aims to  
28 stretch the plastic sheet in a manner adapted for  
29 immediate use in vacuum forming to gain the strength  
30 enhancing benefits of the stretching step.  
31

32 In this application, the term "plastic" refers to any  
33 thermoplastic material.  
34

## 3

According to the present invention there is provided a machine for stretching a rectangular sheet of plastic material, the machine having a first and second orthogonal pairs of opposed clamping means which engageably cooperate with the sides of said sheet and thereby hold said sheet, the machine including a means to controllably urge apart a first pair of opposed clamping means and thereby stretch a sheet held therein, the second pair of clamping means being adapted to allow said sheet to stretch uniformly in the direction in which it is stretched whilst resisting movement of the sides of said sheet in a direction orthogonal to the direction in which it is stretched.

Preferably, the machine includes means to controllably urge apart both pairs of opposed clamping means and thereby stretch a sheet held therein in two dimensions, both pairs of clamping means are adapted to allow said sheet to stretch uniformly parallel to the direction of stretching whilst resisting movement of the sides of said sheet orthogonally to the direction of stretching.

Preferably also, the machine is adapted to stretch the sheet first in one direction and then subsequently in a second direction orthogonal to the first direction.

Preferably, the clamping means are elongate and each comprise a plurality of secondary clamps which engageably clamp a portion of the sheet of plastic material.

More preferably, the secondary clamps are adapted to move along the length of the clamping means proportionately to the stretching of the sheet parallel to the length of the clamping means.

34

1 Most preferably, the secondary clamps are moved along the  
2 length of the clamping means proportionately to the  
3 stretching of the sheet by the motion of said sheet.  
4

5 Preferably, the clamping means further comprise a primary  
6 clamping means which engageably and fixedly clamps a side  
7 of the sheet of plastic material.  
8

9 More preferably, the machine is adapted to vacuum form a  
10 plastic sheet held within the clamping means.  
11

12 Preferably also, the machine comprises a heating means  
13 for evenly heating a plastic sheet held therein.  
14

15 According to a second aspect of the present invention  
16 there is provided a method of stretching a rectangular  
17 sheet of plastic material, the method comprising the  
18 steps of:  
19

20 (a) engageably holding the sides of said sheet; and  
21 (b) stretching said sheet along a first axis of said  
22 sheet whilst holding the sides of said sheet  
23 parallel to the first axis so as to allow the sheet  
24 to stretch uniformly along the first axis but so as  
25 to resist deformation of the sides of said sheet  
26 orthogonal to the first axis.  
27

28 Preferably, the method further comprises the step of  
29 stretching said sheet along a second axis of said sheet  
30 whilst holding the sides of said sheet parallel to the  
31 second axis so as to allow the sheet to stretch uniformly  
32 along the second axis but so as to resist deformation of  
33 the sides of said sheet orthogonal to the second axis,  
34 wherein the second axis is orthogonal to the first axis.



Preferably, the machine includes means to controllably  
urge apart both pairs of opposed clamping means and  
thereby stretch a sheet held therein in two dimensions,  
both pairs of clamping means are adapted to allow said  
sheet to stretch uniformly parallel to the direction of  
stretching whilst resisting movement of the sides of said  
sheet orthogonally to the direction of stretching.

Preferably, the sides of said sheet are engageably held  
by a first and second orthogonal pairs of clamping means  
which each engageably cooperate with a side of said  
sheet.

More preferably, said sheet is stretched along a first  
axis by a means to controllably urge apart a first pair  
of opposed clamping means and thereby stretch a sheet  
held therein, the second pair of clamping means being  
adapted to allow said sheet to stretch uniformly in a  
direction parallel to the clamping means whilst resisting  
movement of the sides of said sheet in a direction  
orthogonal to the clamping means.

Preferably, the clamping means comprises a plurality of  
secondary clamps which engageably clamp a portion of the  
sheet of plastic material.

More preferably, the secondary clamps are adapted to move  
along the length of the clamping means proportionately to  
the stretching of the sheet along an axis parallel to the  
clamping means.

Most preferably, the secondary clamps are moved along the  
length of the clamping means proportionately to the

6

1 stretching of the sheet along an axis parallel to the  
2 clamping means by the motion of said sheet.

3

4 Preferably, the method further comprises the step of  
5 engageably and fixedly clamping the sides of the sheet of  
6 plastic material with a plurality of primary clamping  
7 means.

8

9 Preferably also, the method includes the step of evenly  
10 heating the sheet of plastic material.

11

12 According to a third aspect of the present invention,  
13 there is provided a method of vacuum forming a sheet of  
14 plastic material comprising the steps of stretching a  
15 sheet of plastic material according to the second aspect  
16 above and then vacuum forming said sheet of plastic  
17 material.

18

19 An example embodiment of the present invention will now  
20 be illustrated with reference to the following figures in  
21 which:

22 Figure 1 is a plan view of a plastic sheet  
23 stretching machine;

24 Figure 2 is a cross-section through a plastic  
25 stretching machine along line AA;

26 Figure 3 is a perspective view of a plastic  
27 stretching machine according to the present  
28 invention; and

29 Figure 4 shows a plan for cutting up sheets of  
30 material in a conventional fashion and in a fashion  
31 for use with the present invention.

32

33 A plastic stretching machine is intended for use with a  
34 rectangular sheet of plastic material or any other vacuum

7

formable material. Four clamping bars are provided, one to clamp each edge of the rectangular plastic sheet.

Clamping bars 1 and 3 oppose each other, as do clamping bars 2 and 4. Clamping bars 1 and 2 are fixed in place, whereas clamping bars 3 and 4 may be moved, as controlled by a programmable logic controller.

Each clamping bar 1, 2, 3 and 4 comprises a plurality of secondary clamping means 5 (only some of which are labelled in Figure 1). These clamping means are mounted upon each clamp bar and may move along its length with a low co-efficient of friction.

A rectangular hot thermoplastic sheet is placed within the device and is clamped around its four edges by the secondary clamps 5. This apparatus is shown in cross-section along line AA in Figure 2.

Actuator 6 activates the clamping mechanism. This causes the clamping head to be rotated around joint 7 on support assembly 8 and the plastic sheet is held in the secondary clamps 5 between plates 9 and 10. Alternate pairs of clamp bars are then pulled apart. For example, whilst clamp bar 1 is held in place, clamp bar 3 may be moved away from it, stretching the plastic sheet in the longitudinal direction. Clamp bars 2 and 4 do not move. However, the secondary clamps 5 are free to move along the clamp bars. They are pulled along by the material sheet and therefore move proportionately to the movement of clamp bar 3. They act to resist scalloping of the plastic sheet.

Similarly, clamp bar 4 can be moved away from clamp bar 2, whilst clamp bar 1 and clamp bar 3 remain in place.

1 Again, the clamping means move proportionately to the  
2 stretching of the sheet cause by movement in clamping bar  
3 4 and prevent scalloping. In order for this to work  
4 there has to be very low friction preventing the movement  
5 of the secondary clamping means.

6

7 Once the stretching phase has been completed, an actuator  
8 11 acting through a thrust pin 12 engages a primary  
9 clamping means which is provided on each clamped set and  
10 comprises a top plate 13 and bottom plate 14 within which  
11 the plastic sheet is securely held. All four sides are  
12 held at once.

13

14 A mould is then driven up through the clamped sheet  
15 forming a seal. The mould is then vacuumed by  
16 conventional means to form the resulting mould. At the  
17 end of this complete product cycle the secondary clamp  
18 carriages 5 are returned to their initial positions by  
19 the action of the primary clamp bars. A series of  
20 linkages prevent the secondary clamps 5 from getting too  
21 close to each other.

22

23 The machine also provides zoned cooling for control of  
24 thickness distribution in the final product. This is a  
25 technique used in the prior art.

26

27 The entire process cycle involving both the timings and  
28 movements is controlled by a computer or controlled  
29 programme logic controller. As a result of this machine  
30 it becomes possible to make considerable savings in raw  
31 material costs; for example, experiments have indicated  
32 that savings of 30% - 50% can be readily achieved. This  
33 could not be achieved simply by vacuum forming a thinner  
34 sheet of thermoplastic as only the strength benefits

1 provided by the stretching step allow this lower volume  
2 of plastic to be used.

3

4 Figure 4 (a) shows a conventional method for cutting up a  
5 sheet of plastic that is 3100mm x 1800mm to form four  
6 rectangular pieces 1750mm x 750mm for use in making a  
7 product sized 1700mm x 700mm. Note that offcuts are left  
8 around the edge. Figure 4 (b) shows how this same sheet  
9 can be cut into six rectangular pieces 1550mm x 600mm  
10 without offcuts, that may be stretched then used to give  
11 a product sized 1700mm x 700mm as before.

12

13 This reduces the time required and the space requirements  
14 for storing raw material. Additionally, fewer different  
15 sizes of sheet will have to be stocked by a manufacturer.  
16 These benefits represent a substantial cut in the cost of  
17 manufacturing the product, therefore providing an  
18 important commercial advantage.

19

20 It will be clear to one skilled in the art that this  
21 technique can be used with acrylic plastic or any other  
22 vacuum formable material. Furthermore, this plastic  
23 stretching technique will find applications in areas  
24 other than just vacuum forming.

25

26 Further modifications and improvements may be  
27 incorporated without departing from the scope of the  
28 invention herein.

29

30 Throughout this application, unless the context requires  
31 otherwise, the word "comprise" or variations such as  
32 "comprises" or "comprising" will be understood to imply  
33 the inclusion of a stated integer or group of integers

10

- 1 but not the exclusion of any other integer or group of
- 2 integers.

1 / 4

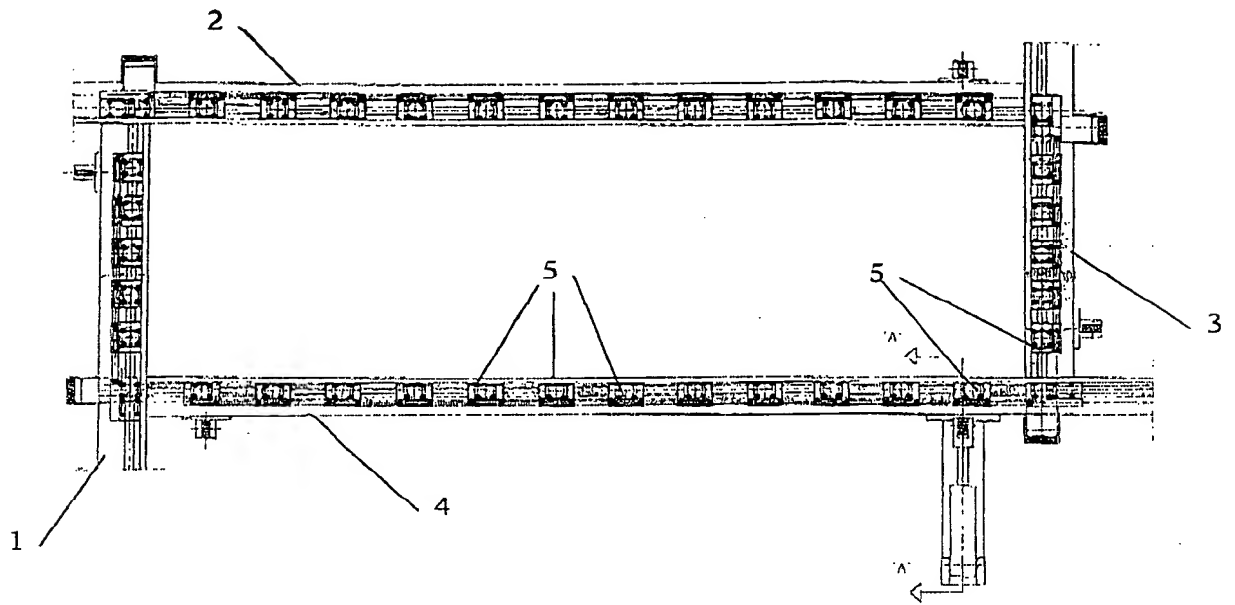


Figure 1





2 / 4

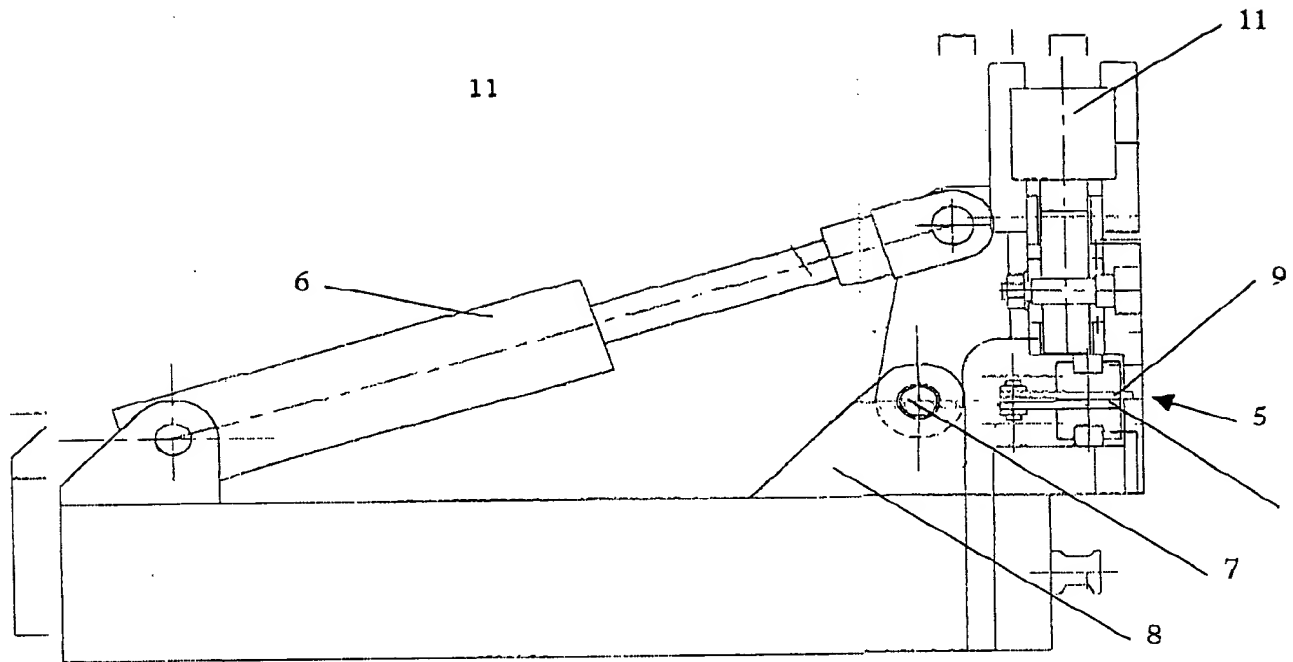


Figure 2



3 / 4

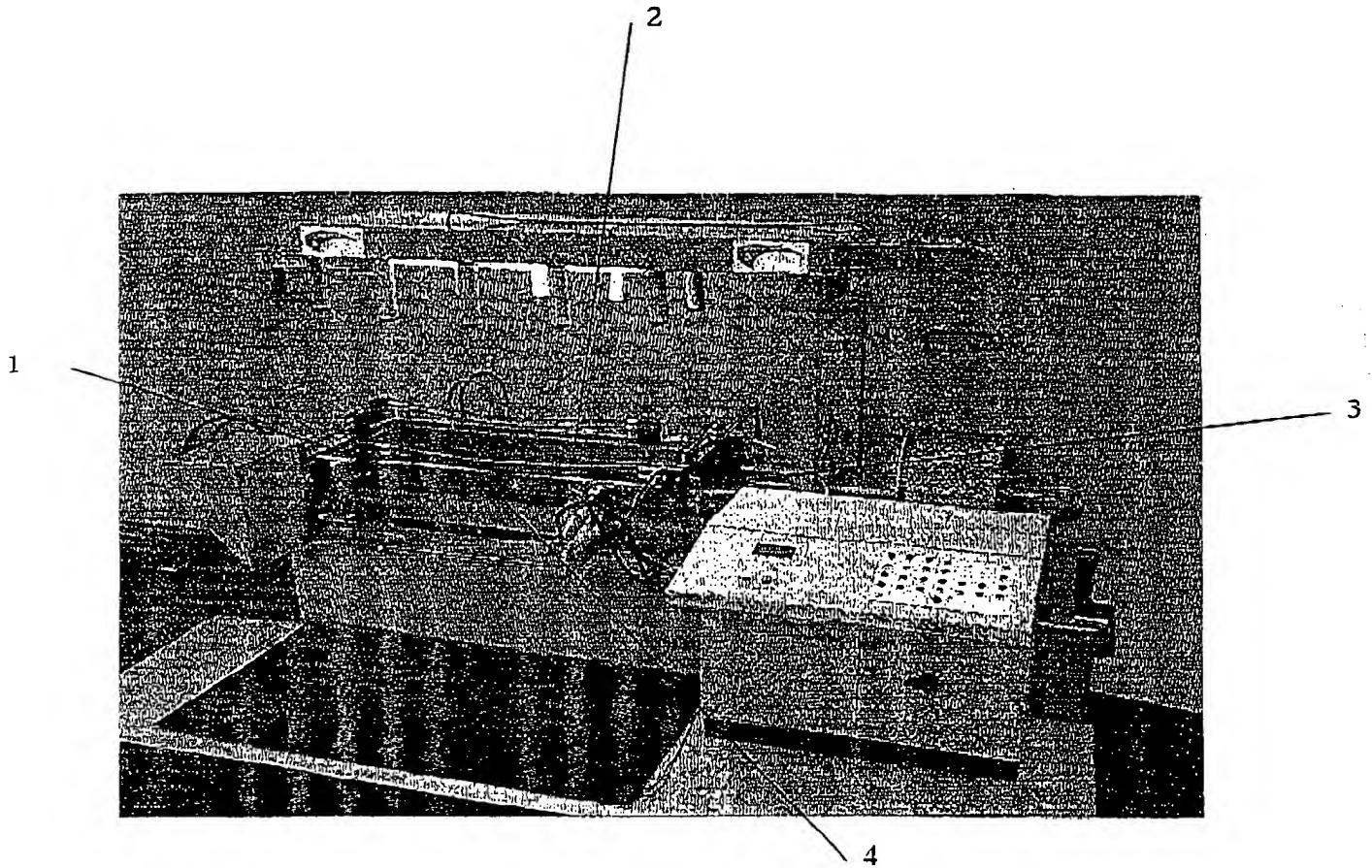


Figure 3



4 / 4

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(a)


(b)

**Figure 4**

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